IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the application of: **Pezeshki et al** Group Art Unit: **2828**

Application Number: **09/912,876**

Filed: **07/25/2001** Examiner: **MENEFEE, James A**

For: **WAVEGUIDE WAVELENGTH LOCKER**

DECLARATION UNDER 37 CFR 1.131

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

City of Fremont
State of California,

I, Bardia Pezeshki, and Edward C. Vail declare that all statements made of my own knowledge are true, and that all statements made on information and belief are believed to be true:

1. I am an applicant of the above-identified patent application and an inventor of the subject matter described and claimed therein.

2. Prior to December 17, 1999, I, along with Edward C. Vail conceived the idea of a waveguide wavelength locker as described and claimed in our application.

3. Attached hereto is an invention disclosure form marked as exhibit A. On 10/1/1999 Edward C. Vail and I signed this disclosure form, provided by SDL Corporation which discloses the invention claimed in the instant patent application. Exhibit A describes the limitations of prior art wavelockers and clearly describes the claimed invention by way of a detailed description and drawings which correspond to the description and drawings in the instant above mentioned application.

4. Attached hereto are three typewritten sheets marked as exhibit B which we wrote prior to December 19, 1999 clearly teaching our claimed invention.

5. I acknowledge that willful false statements and the like are punishable by fine and/or imprisonment, and may jeopardize the validity of the application or any patent issuing therefrom.

Sworn at Fremont, CA in the State of California, this 25 day of November, 2003

Bardia Pezshki

Sworn at Fremont, CA in the State of California, this 25 day of November, 2003

Edward C. Vail

WP1259

ID 2,012

To: SDL Patent Operations

1	**Bardia Pezeshki**	Organization, Building & Extension **R&D 80 x4244**
2	**Ed Vail**	Organization, Building & Extension **R&D 80**
*3	Proposal Submitted By (Use Legal Name - First , Middle Last)	Organization, Building & Extension

* If space for additional submitters is required, please use an additional form. Each named submitter must also sign and date each page of the Disclosure.

Descriptive Title of Invention Disclosure:

Waveguide Wavelength locker

Indicate any Program or Product Name and any Expected Date of Sale or Shipment:

If This Disclosure is Funded Under a Contract, Provide the Contract Number, Customer Name and Customer Program Name:

If a Prototype is to be Delivered, Based Upon the Disclosure, Indicate the Expected Date of Sale or Shipment of the Prototype:

If any Portion of This Disclosure Has Been Previously Published or Presented in an Outside Presentation, Indicate the Date of Disclosure and the Portion Disclosed:

Names of Others Known to Have Worked on the Same Product or Technology and Citation of Known Published Works: **

** Attach Copies of any papers or patents if submitter(s) already has copies.

Description of Concept and Embodiments:

(The preferred form is to include background information on invention and existing problems, followed by description of the proposed invention with drawings and a discussion as how the new concept improves over present technology. It is permissible to attach copies of materials such as lab notebook pages, memos, drawings, etc. and to refer to such items in the body of the description below, providing all such materials, including this Invention Disclosure, are signed and dated by each named submitter(s) and the witness.)

Background

Wavelength lockers are needed for WDM systems with narrow channel spacings. They are especially important for tunable lasers, where they need to provide a lock to the ITU wavelength channels. An ideal wavelength locker would be able to provide a lock to multiple channels.

Currently wavelength lockers are based either on fiber gratings or Fabry-Perot etalons. Since fiber gratings are narrow band and can only be made serially in a fiber, they generally can lock onto only one or a few channels. For example, a tunable laser with 12nm tuning range can access 32 channels spaced 50GHz apart. A fiber grating that can provide a lock to all the channels needs to have 32 separate gratings. This becomes quite complex to implement.

Alternatively, one may use a bulk Fabry-Perot etalon with a precise thickness that has resonances at multiple wavelengths (as described in Nortel patent US5798859). This technique is compact and can therefore be integrated into the laser package. A temperature insensitive etalon can be fabricated by using a combination of materials whose thermal expansion coefficents are set for zero total change with temperature. This obviates the need for additional temperature stabilization, but requires extremely careful alignment to set the precise wavelength of the etalon. Alternatively, a solid material can be used as the etalon which would have some temperature sensitivity. In this case, the etalon must be temperature stabilized, but the precise wavelength can be simply adjusted by varying the operating temperature set point.

Witnessed and Understood By:	Date: 10/1/99
Submitter(s) Signature(s): Bardia Pezeshki	Date(s): 10/1/99 10/1/99

B. Pezeshki

K. Dzurko
R. Lang
R. Parke
D. Mehuys
D. Scifres
D. Carothers
R. Nagarajan
D. Welch

Exhibit A

1D2,012

As a design example, consider a wavelength locking etalon for a 12nm tunable laser at 50GHz channel spacing. For both temperature insensitive and sensitive packages, the exact channel spacing can be fine-tuned by the tilt of the etalon. For example, a 2mm thick piece of quartz has a channel spacing of 51GHz. This can be adjusted to 50GHz by tilting it to an angle of 13.26 degrees. In order to keep the channels aligned to 1/10 the channel spacing over 12nm, one requires the spacing to be within 1/10 x 1/32 of the channel spacing, or about 0.16GHz. This requires a tilt alignment accuracy of 0.1 degree. For the temperature insensitive package, the absolute wavelength must also be adjusted with tilt, which for 1/10 the channel spacing translates to a tilt alignment of 1/200 of a degree accuracy. The temperature-sensitive package, however, can be set by controlling the operating temperature, in the case of quartz, with a required accuracy of 4 degrees C.

In both cases, we find exact alignment is a real issue. Even for the temperature sensitive package, the 1/10 of a degree alignment can be difficult in a manufacturing environment. What is needed is a technique where exact alignment and spacing can be done once lithographically, and without careful alignment in the package.

Invention

In fact lithographically fabricated waveguides can have very high precision that is detemined by the masks used and is highly reproducible. A waveguide wavelength locker, fabricated with planar glass waveguides, can provide very accurate locking without need for careful adjustment. For wavelength locking, accurate coupling to the waveguide is also not required, since very little optical power is needed for the slow feedback loop. Fig. 1 shows an exemplary implementation of this technique.

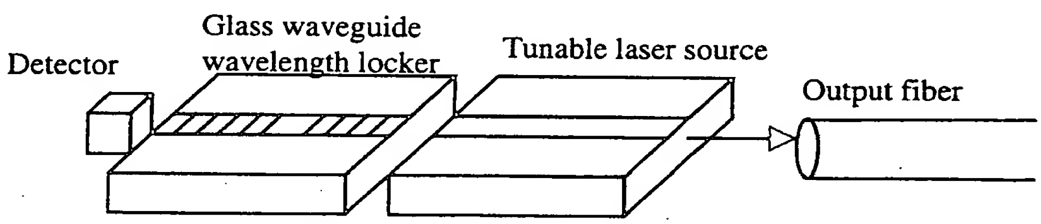

Fig. 1: exemplary implementation

In this case, a glass wavelength locker is positioned at the rear of the tunable laser chip, or at an exit tap where some power is available. The alignment can be very rough, as only a very small amount of power needs to be coupled into the glass waveguide. In fact, a "poor" alignment may be important to prevent feedback back into the laser that could destablize the device. Slow cheap detectors can easily measure –70dBm power levels, at which level there is negligible feedback into the laser. Note that careful angular alignment is not required, as the material and lithographic parameters determine the effective index of the waveguide mode and the associated wavelength resonances. These can be precisely determined in the fabrication process, and adjusted by temperature tuning in the final package , if necessary. Alternative post fabrication tuning techniques can be used, such as UV irradation, controlled etching or deposition of layers, or even adjustment of strain.

The glass waveguide may have one or more frequency discriminating elements. The simplest would be the equivalent of a Fabry-Perot resonator used in the bulk version. In this case two strong gratings would act as broadband reflectors and be spaced a precise distance apart from each other. Unlike optical

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Submitter(s) Signature(s):	Date(s): 10/1/99
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Exhibit A

fibers, where gratings are produced by UV irradiation and thus are narrow band, integrated optics gratings can be etched and can easily span a 12nm band. Alternatively, Mach-Zehnder structures with unequal path lengths can be implemented that have similar periodic resonances in frequency – the arrayed waveguide grating, being a special case of the Mach-Zehnder.

At the output of the frequency-selective waveguide would be one or more detectors. By taking ratio of the emitted laser power to the received power, one can generate an error signal that depends on the wavelength, and can be used to vary the temperature of the laser in a feedback loop. If more than one detector is used with differing wavelength response at each detector, then the ratio of these two powers can be used to generate the error signal. The feedback loops would be similar to those described in the prior art.

A tremendous advantage of planar waveguides is the very high levels of functionality that can be obtained. Fig. 2 shows a structure where a planar waveguide incorporates a Mach-Zehnder with unequal arms for the generation of a wavelength locking signal, a grating for an absolute reference, and a passive splitter for measuring the total laser power.

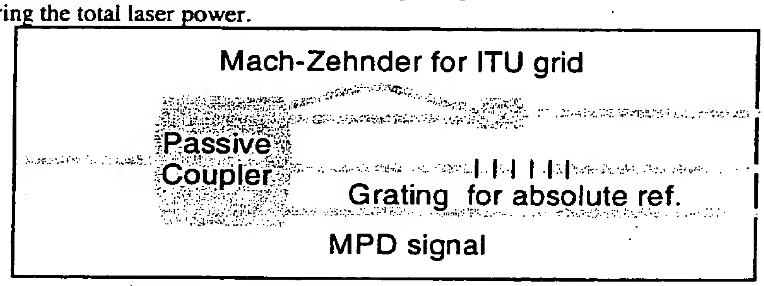

Figure 2 – Wavelength locker with higher functionality.

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Exhibit A

Invention

In fact lithographically fabricated waveguides can have very high precision that is detemined by the masks used and is highly reproducible. A waveguide wavelength locker, fabricated with planar glass waveguides, can provide very accurate locking without need for careful adjustment. For wavelength locking, accurate coupling to the waveguide is also not required, since very little optical power is needed for the slow feedback loop. Fig. 1 shows an exemplary implementation of this technique.

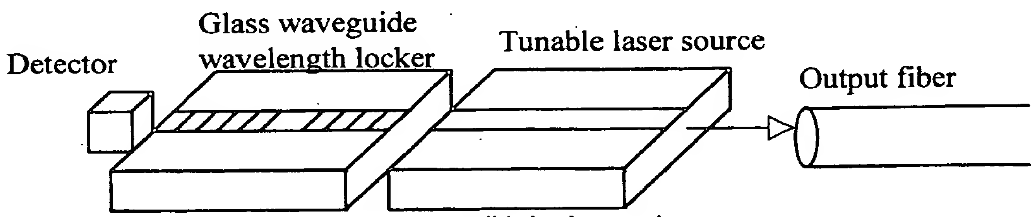

Fig. 1: Possible implementation

In this case, a glass wavelength locker is positioned at the rear of the tunable laser chip, or at an exit tap where some power is available. The alignment can be very rough, as only a very small amount of power needs to be coupled into the glass waveguide. In fact, a "poor" alignment may be important to prevent feedback back into the laser that could destablize the device. Slow cheap detectors can easily measure –70dBm power levels, at which level there is negligible feedback into the laser. Note that careful angular alignment is not required, as the material and lithographic parameters determine the effective index of the waveguide mode and the associated wavelength resonances. These can be precisely determined in the fabrication process, and adjusted by temperature tuning in the final package , if necessary. Alternative post fabrication tuning techniques can be used, such as UV irradation, controlled etching or deposition of layers, or even adjustment of strain.

The glass waveguide may have one or more frequency discriminating elements. The simplest would be the equivalent of a Fabry-Perot resonator used in the bulk version. In this case two strong gratings would act as broadband reflectors and be spaced a precise distance apart from each other. Unlike optical fibers, where gratings are produced by UV irradiation and thus are narrow band, integrated optics gratings can be etched and can easily span a 12nm band. Alternatively, Mach-Zehnder structures with unequal path lengths can be implemented that have similar periodic resonances in frequency – the arrayed waveguide grating, being a special case of the Mach-Zehnder.

At the output of the frequency-selective waveguide would be one or more detectors. By taking ratio of the emitted laser power to the received power, one can generate an error signal that depends on the wavelength, and can be used to vary the temperature of the laser in a feedback loop. If more than one detector is used with differing wavelength response at each detector, then the ratio of these two powers can be used to generate the error signal. The feedback loops would be similar to those described in the prior art.

A tremendous advantage of planar waveguides is the very high levels of functionality that can be obtained. Fig. 2 shows a structure where a planar waveguide incorporates a Mach-Zehnder with unequal arms for the generation of a wavelength locking signal, a grating for an absolute reference, and a passive splitter for measuring the total laser power. In the figure only one output of the Mach-Zehnder is shown. Of course both outputs could be monitored to get a differential signal for better accuracy.

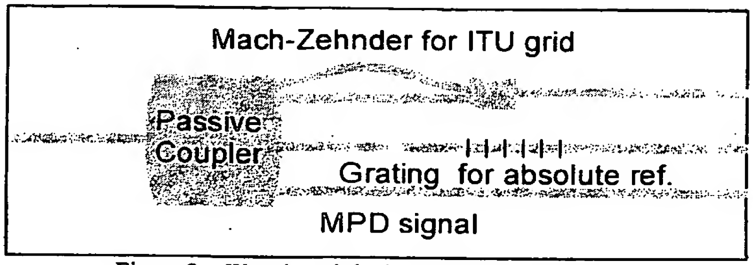

Figure 2 – Wavelength locker with higher functionality.

Since the easiest implementation would be to place the planar waveguide wavelength locker on the same temperature controlled stage as the laser, one would always have an accurate temperature reading of the device, and given the well-known and reproducible temperature characteristics of glass, the absolute wavelength can be found by taking this dependence into account.

The preferred embodiment, shown in Fig. 3 shows a series of Mach Zehnders with differently spaced arms, and a series of photodetectors to monitor the output of the arms. In addition, there is a straight through path to act as a power reference for normalizion.

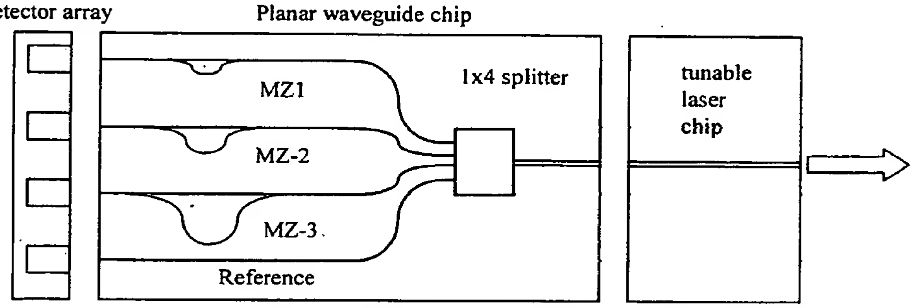

Fig. 3: Planar waveguide locker with 3 Mach-Zehnders

The response of the Mach-Zehnders, divided by the reference signal is shown in Fig. 4, assuming the asymmetry of each M-Z is double of the previous device – one obtains a unique signal for the wavelength. This value can be corrected for temperature if the planar waveguide chip is mounted on the same temperature controlled platform as the tunable laser chip.

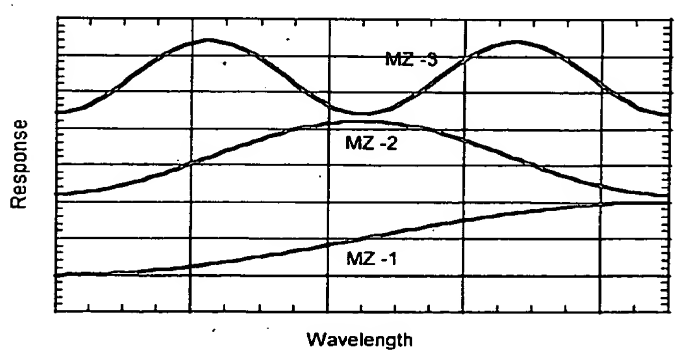

Fig. 4: Response of the M-Zs of fig. 3

Possible Claims:

1) A planar waveguide chip containing wavelength selective devices, packaged together with a semiconductor laser and one or more detectors to provide a wavelength selective electrical signal from the detectors that is in turn used in a control feedback loop to adjust the wavelength of the laser

2) Device of claim (1) where the planar waveguide chip contains at least one Mach-Zehnder interferometer.

3) Device of claim (1) where the planar waveguide chip contains a splitter to divide the power into different optical circuits

4) Device of claim (1) where there is a plurality of Mach-Zehnder interferometers, with different asymmetries

5) Device of claim(1) where the planar waveguide device is mounted on the same temperature controlled stage as the tunable laser and the value of the temperature of the stage is used to compensate in the calculation of the measured wavelength

6) Device of clam (4) where the Mach-Zehnders are fabricated such that the frequency response of each Mach-Zehnder is roughly double the previous device to provide a unique wavelength reading